Police versus Military Ammunition – Design, Wound Ballistics and Standards

PL Gotts

Phil Gotts Consulting Ltd, 23 Thorney Rd, Capel St Mary, Ipswich, Suffolk, IP9 2HL, UK
phil@philgotts.com

Abstract. The designs of ammunition for police use and military use are often different, as the requirements for the interaction with the target are different. Police ammunition needs to stop an individual target, without the possibility of shoot-through which could cause collateral injuries or fatalities. Military ammunition is mainly designed to cause casualties rather than fatalities, and hence there is no requirement to stop the bullet in a single target. For these reasons, military ammunition is predominantly full metal jacket (FMJ) ball ammunition, whereas much police ammunition is now of the expanding type, which, in accordance with international law, is not legal for military use. The two ammunition design types may be compared by studying the wound ballistic effects in gelatine, examining such parameters as depth of penetration, and volume of the temporary cavity. Expanding ammunition also exhibits a tendency to break up within tissue and this can also be demonstrated within gelatine. Historically, personal armour test standards, whether for police or military, have used FMJ ball ammunition, particularly for the high velocity rifle levels. A recent exception for this is the UK Home Office 2017 Body Armour standard, which uses expanding ammunition as options in most levels, including those for high velocity rifle bullets. What are the implications for personal armour of these different ammunition types? Can it always be assumed that FMJ ball ammunition will be a more severe threat to personal armour than expanding ammunition? Although the wound ballistics parameters measured do not impinge on the design of the armour, they are the results of designing the projectile differently to meet a specific operational requirement. The need for different wound ballistics characteristics leads to a necessary design of the bullet. This means that the geometry of the nose of the bullet impacting armour is therefore different between the two designs. For hard armour this design has little effect upon the terminal ballistics, but for soft armour there is more scope for differences to be observed. It is for this reason that both HO CAST and VPAM have included expanding hollow point ammunition within their standards as well as FMJ ammunition. A final consideration with police ammunition is that relating to whether it should be specified to defeat, or be stopped by, personal armour systems, including those worn by the police officers themselves. Military and Police ammunition are designed differently to meet different requirements.

1. INTRODUCTION

The designs of ammunition for police use and military use are often different, as the requirements for the interaction with the target are different. Police ammunition needs to stop an individual target, without the possibility of shoot-through which could cause collateral injuries or fatalities. Military ammunition is mainly designed to cause casualties rather than fatalities, and hence there is no requirement to stop the bullet in a single target.

For these reasons, military ammunition is predominantly full metal jacket ball ammunition, whereas much police ammunition is now of the expanding type, which, in accordance with international law [1], is not legal for military / warfare use. The two ammunition design types may be compared by studying the wound ballistic effects in gelatine, which is a method used for such purposes for many decades [2]. The gelatine may be used for assessing such parameters as depth of penetration [3], and volume of the temporary cavity. Expanding ammunition also exhibits a tendency to break up within tissue and this can also be demonstrated within gelatine, by considering the retained mass of the recovered bullet [4].

Historically, personal armour test standards, whether for police or military, have used FMJ ball ammunition, particularly for the high velocity rifle levels. A recent exception for this is the UK Home Office 2017 Body Armour standard [5], which uses expanding ammunition as options in most levels, including those for high velocity rifle bullets. Expanding ammunition is also included for some calibres in the VPAM (Vereinigung der Prüfstellen für angriffshemmende Materialien und Konstruktionen) AND-SoM [6] supplement entitled Ammunition Types for Special Tests.

A final consideration with police ammunition is that relating to whether it should be specified to defeat, or be stopped by, personal armour systems, including those worn by the police officers themselves.

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2. AMMUNITION DESIGNS AND OPERATION

Small arms ammunition (SAA) is designed to impart kinetic energy into the target from a significant distance away.

There are many different ammunition types designed for use in different scenarios, by different users, with different requirements. Ammunition is designed to:

- Kill,
- Incapacitate,
- Injure,
- Suppress and
- Deter

The requirements are not the same for each of these. Military ammunition is predominantly designed to injure and suppress. Police ammunition is designed to incapacitate and deter. The design of the ammunition to meet these different requirements is also not the same. For suppression and as a deterrent the ammunition has no real design requirements, except perhaps noise is useful for suppression. For injuring, it is probably useful for the ammunition to have full-metal jacket (FMJ) bullets, whereas for incapacitation, where it is desirable to dump the kinetic energy into the target rapidly, expanding bullets of the soft point or hollow point design are preferable.

For a bullet to operate as an expanding bullet, it needs to expand upon, or very soon after, impact. This means that upon impact the target needs to exert an appropriate pressure upon the tip of the bullet to promote the required expansion. The exerted pressure is related to the velocity of the impact. Therefore, for the ammunition to function as per its design, there will be a velocity range over which it is expected to impact the target. For this reason, testing with ballistic gelatine is conducted with ammunition fired from specified distances, and the impact velocity measured.

3. COMPARISON OF POLICE AND MILITARY AMMUNITION

On the whole, military ammunition is designed to inflict casualties rather than fatalities. On the battlefield a casualty is a greater logistical burden than a fatality, and hence more desirable for the mission. Therefore, a bullet which passes through the target completely is fully acceptable. It should however dump sufficient energy into the target to produce a significant injury.

The aim of police ammunition is to immediately incapacitate the target, without endangering the life of innocent bystanders. This incapacitation is achieved by dumping as much of the bullet's energy as possible into the desired target. The preservation of the life of innocent bystanders is achieved by retaining the bullet within the target.

For the purposes of this paper, it is assumed that military ammunition is of the full metal jacket type, and that police ammunition is of the expanding type.

For military ammunition the muzzle velocity is advantageous to be as high as possible whilst complying with any pressure restrictions of the weapon. A high muzzle velocity is advantageous for accuracy and lethal range requirements, as the kinetic energy is related to the velocity squared.

One way of highlighting the differences between the two ammunition types is to compare them through ballistic gelatine-based experiments. The following comparison was achieved from different series of tests, conducted using identical protocols, which have now been brought together and referenced for comparison purposes.

4. COMPARISON BY WOUND BALLISTICS

Typically, the wound ballistic effects of a projectile are assessed by studying the effects as it passes through a block of ballistic gelatine. Unfortunately, there is often also a difference between how this assessment is conducted for police and military ammunition. Military ammunition tends to be tested using 20 % gelatine at room temperature, while Police ammunition tends to be assessed using 10 % gelatine at 4 ºC. For the following comparison, all the firings are conducted with the same specification of gelatine, being 10 % at 4 ºC. Two ammunition calibres are used as case studies, being 9 x 19 mm and 5.56 x 45 mm.

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The wound ballistic assessments include three parameters:

- Depth of penetration into the gelatine
- Estimated maximum volume of the temporary cavity
- Retained mass of the recovered bullet

These parameters are particularly important for police ammunition, which have strict requirements for each of these parameters. For each of these parameters, examples of both full metal jacket (FMJ) and jacketed hollow-point (JHP) ammunition are compared.

4.1 Depth of Penetration

For police ammunition, the depth of penetration achieved is critical, and must be within specified limits, being between 250 mm and 500 mm [3]. If the depth of penetration is below 250 mm it is deemed to be insufficient to cause the required incapacitation of the target. If the depth of penetration is greater than 500 mm it is considered likely to cause a shoot-through, thus endangering the lives of innocent bystanders. There is also a requirement to dump all the bullet's energy within the target, which does not occur in the event of a shoot-through.

4.1.1 9 x 19 mm Ammunition

The following photographs show the gelatine block with the permanent cavity. For the military 9 mm FMJ the bullet passed completely through the 560 mm long block. It was captured in a follow-on block, giving a total depth of penetration of 715 mm. In contrast, the 9 mm hollow-point police ammunition stopped at 362 mm in the original block meaning that it passed the depth of penetration requirement for police ammunition.

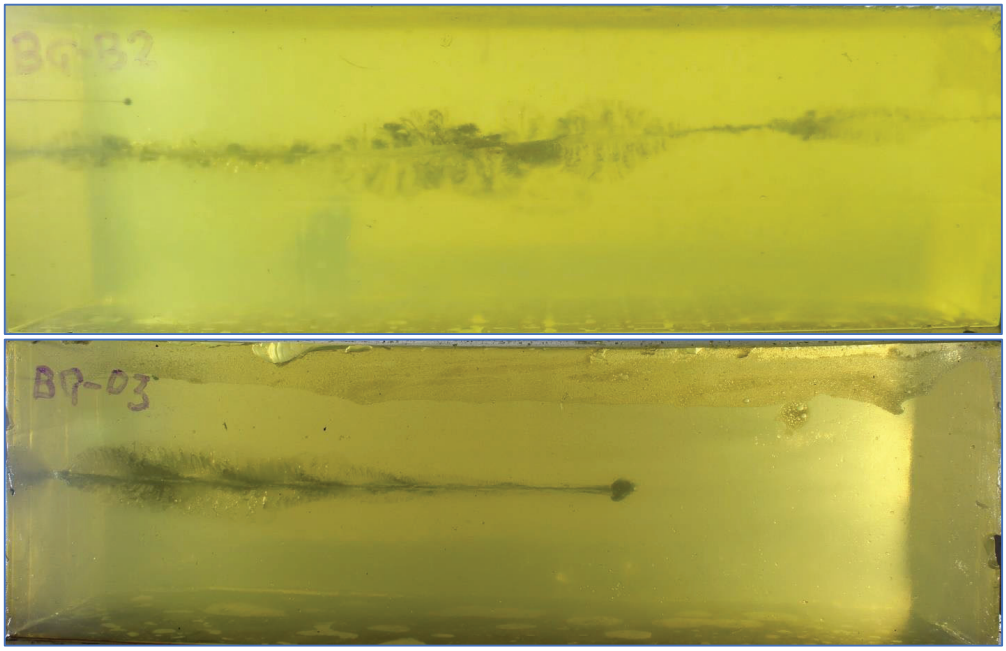

Figure 1. Permanent Cavity for 9 mm FMJ (upper) and 9 mm HP (lower)

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4.1.2 5.56 x 45 mm Ammunition

The following photographs show the gelatine block with the permanent cavity. For the military 5.56 mm FMJ the bullet passed completely through the 560 mm long block. It was captured in a follow-on block, giving a total depth of penetration of 565 mm. In contrast, the 5.56 mm hollow-point police ammunition stopped at 433 mm in the original block meaning that it passed the depth of penetration requirement for police ammunition.

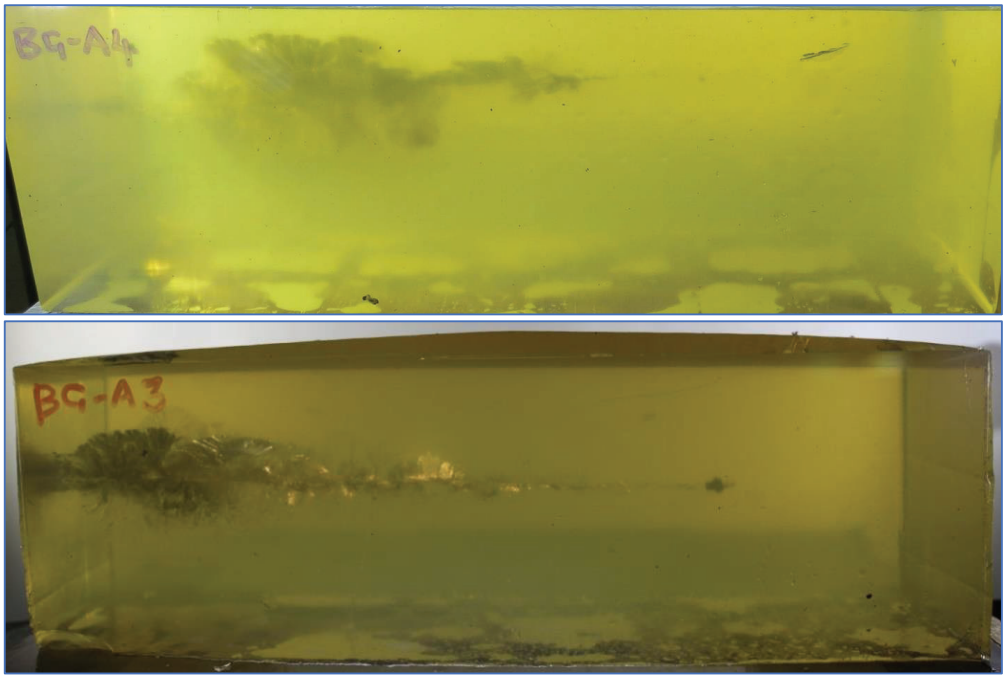

Figure 2. Permanent Cavity for 5.56 mm FMJ (upper) and 5.56 mm HP (lower)

4.2 Estimated Maximum Volume of Temporary Cavity

The maximum volume of the temporary cavity is an indication of the quantity of energy imparted to the gelatine. The assessment of the maximum volume of the temporary cavity in this case is conducted using the still image of high-speed footage, and using bespoke software to estimate the volume, by dividing the cavity into a series of truncated cones. This does, of course, assume that the cavity is symmetrical around the bullet axis. It should be noted that for police ammunition the temporary cavity is usually a single cavity, whereas with military ammunition there may be multiple temporary cavities in the length of the gelatine block.

4.2.1 9 x 19 mm Ammunition

The following photographs show the gelatine block with the temporary cavity as a still image taken from the high-speed video. For the military 9 mm FMJ the estimated maximum temporary cavity volume was 1,236 cm^3. This volume was that combined from all temporary cavities up to the stopping point. In contrast, the estimated maximum temporary cavity volume for the 9 mm hollow-point police ammunition was 1,398 cm^3, obtained from a single cavity.

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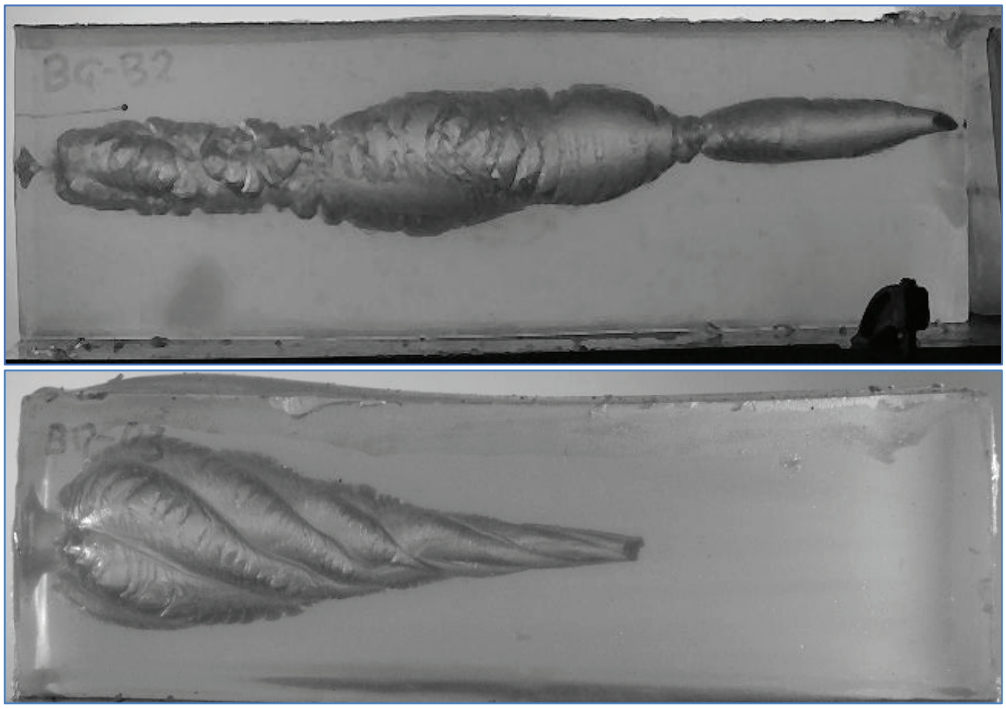

Figure 3. Temporary Cavity for 9 mm FMJ (upper) and 9 mm HP (lower)

4.2.2 5.56 x 45 mm Ammunition

The following photographs show the gelatine block with the temporary cavity as a still image taken from the high-speed video. For the military 5.56 mm FMJ the estimated maximum temporary cavity volume was 3,290 cm^3. This volume was that combined from all temporary cavities up to the stopping point. In contrast, the estimated maximum temporary cavity volume for the 5.56 mm hollow-point police ammunition was 2,592 cm^3, obtained from a single cavity.

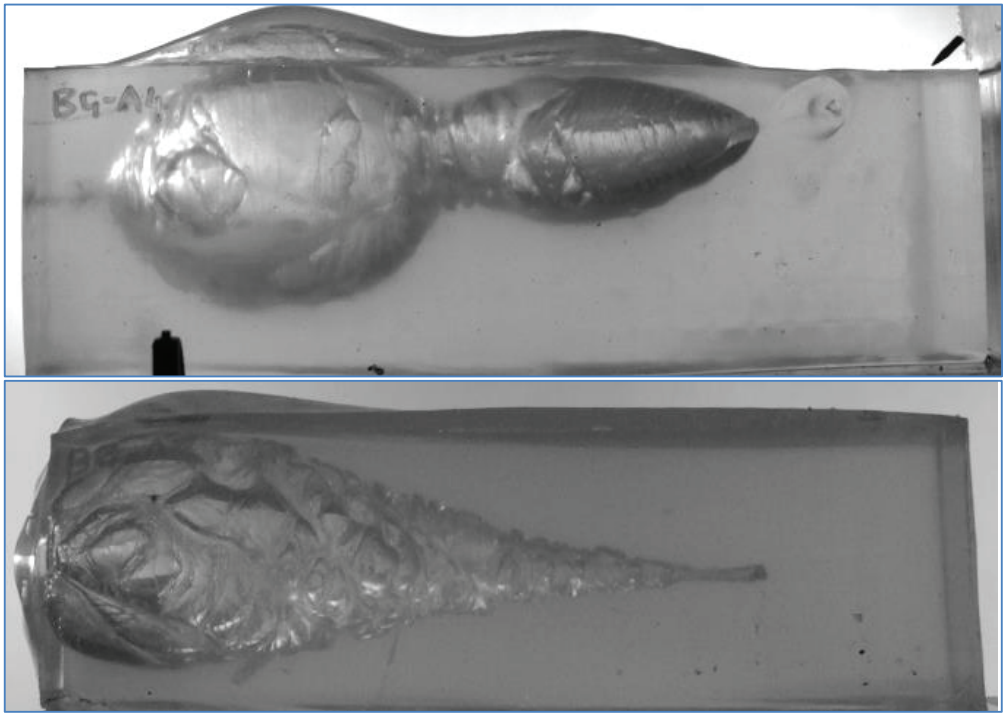

Figure 4. Temporary Cavity for 5.56 mm FMJ (upper) and 5.56 mm HP (lower)

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4.3 Retained Mass of Recovered Bullet

If the bullet is retained within the gelatine, it may be complete, or it may have fragmented into a number of parts. For police ammunition it is desirable that the bullet in the target remains complete. Should it have broken up, the mass of the largest part is considered to be the retained mass. This is then reported as a percentage of the original pre-fired bullet mass. For police ammunition there are minimum percentage retained mass values that must be achieved.

4.3.1 9 x 19 mm Ammunition

Figure 5 below shows a comparison of the recovered 9 mm FMJ and a 9 mm JHP. The 9 mm FMJ looks very similar to the pre-fired bullet, with the obvious addition of the rifling striations. The 9 mm JHP bears little resemblance to the fired bullet. It should be noted that different designs of 9 mm JHP look quite different after recovery, whereas most 9 mm FMJ will look similar after recovery.

Figure 5. Pre-Fired (left) and Recovered 9 mm FMJ (upper) and 9 mm HP (lower)

4.3.2 5.56 x 45 mm Ammunition

Figure 6 below shows a comparison of the recovered 5.56 mm FMJ and a 5.56 mm JHP. The 5.56 mm FMJ looks very similar to the pre-fired bullet, with the obvious addition of the rifling striations. The flattening was caused by impact with the floor after leaving the gelatine block. The 5.56 mm JHP bears little resemblance to the fired bullet. It should be noted that different designs of 5.56 mm JHP look quite different after recovery, whereas most 5.56 mm FMJ will look similar after recovery.

Figure 6. Pre-Fired (left) and Recovered 5.56 mm FMJ (upper) and 5.56 mm HP (lower)

4.4 Summary of Wound Ballistics Results

Table 1 below shows the summary of the results obtained from the comparison of the wound ballistics for the 2 calibres and the 2 types of ammunition for each calibre. The values quoted are the average of 5 results each.

Ammunition	Impact Velocity (m/s)	Depth of Penetration (mm)	Estimated Maximum Temporary Cavity Volume (cm^3)	Percentage Retained Mass (%)
9 mm FMJ	367	715	1,236	100.0
9 mm HP	332	362	1,398	100.0
5.56 mm FMJ	766	565	3,290	95.2
5.56 mm HP	794	433	2,592	99.5

Table 1. Wound Ballistics Results Summary

The table shows that with respect to depth of penetration, both FMJ ammunition types over-penetrate the gelatine block and significantly over-penetrate the 500 mm upper threshold value. The estimated maximum temporary cavity volume for the 9 mm HP is slightly higher than the 9 mm FMJ, and is achieved at a much lower impact velocity. The estimated maximum temporary cavity volume for the 5.56 mm HP is actually lower than the 5.56 mm FMJ, but the FMJ volume is the combined volume of a double cavity which starts further from the entrance to the block. With respect to the percentage retained mass of the recovered bullet, the only type which has lost mass is the 5.56 mm FMJ.

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5. STANDARDS

Body armour standards have included both FMJ and expanding ammunition types for many years, but it is rare that they include direct equivalents of both types in the same level. One standard that does include direct FMJ and expanding bullet equivalents is the same level is the HO CAST Body Armour Standard of 2017. For this reason, it is worth explaining a little bit more detail of the level aspects of this standard.

5.1 HO CAST 2017 Body Armour Standard [1]

The UK Home Office published a body armour test standard in 2017, in which they included both FMJ and JHP versions of 9 mm ammunition:

- HO1 - 9 mm DM11A1B2 (MEN) at 365 ± 10 m/s
  - 9 mm Federal Premium JHP P9HST1 at 365 ± 10 m/s
- HO2 - 9 mm DM11A1B2 (MEN) at 430 ± 10 m/s
  - 9 mm Federal Premium JHP P9HST1 at 430 ± 10 m/s

These levels include 9 mm ammunition of both FMJ and JHP designs. Both projectile types are of the same mass and projected at the same two velocities. It may be expected that the most aggressive of these two ammunition types would be the FMJ, as the JHP is designed to expand on impact with the target.

Level HO3 includes two types of 7.62 mm calibre ammunition, which are both of the FMJ type. These are the 7.62 x 51 mm NATO ball (9.3 g, test velocity 830 ± 15 m/s, 3.20 kJ) and a 7.62 x 39 mm PS ball surrogate (7.9 g, test velocity 705 ± 15 m/s, 1.96 kJ).

Level HO4 includes two further 7.62 mm (.308) calibre ammunition types, which are basically two supplier designations for the same thing. They are listed as the Sako .308 480A Powerhead and the Barnes .308 TSX BT. The Home Office includes them as they are heavier bullets than the NATO or Soviet 7.62 mm military bullets of level HO3 at 10.7g (165 grains). However, they are also both hunting ammunition designed for big game, including, deer, moose, bears and big cats, and are of the solid copper expanding type. At 820 m/s test velocity they produce almost 3.6 kJ kinetic energy, but again the kinetic energy density reduces rapidly upon impact due to the expansion.

6. REQUIREMENT TO DEFEAT BODY ARMOUR, OR NOT?

When designing either ammunition or body armour for either the military or the police user there is a question raised regarding the interaction of the user's ammunition and the user's body armour. Should the user's ammunition defeat the user's armour, or should the user's armour defeat the user's ammunition? This question is considered by the user communities, and the answer is influenced by a number of stakeholders.

The user would like their ammunition to defeat the body armour of their adversary, but unless their own body armour is of a much higher performance than that of their adversary, this will mean that it will defeat their own armour as well. This, therefore, increases the risk of fratricide scenarios. In the military scenario it is probably a reasonable assumption that the enemy will be wearing body armour, whereas in the police example, this is much less likely. Those responsible for the user's health and safety, would prefer their armour would defeat their own ammunition to reduce this risk of fratricide. This however means that their ammunition may have less chance of defeating an adversary's armour.

From the author's experience with both the military and police environments, the preferable decision is for the user's body armour to be capable of defeating the user's ammunition. In the military scenario this includes the ammunition fired by other NATO allies. Therefore, most military body armour requirements specify the defeat of the user's own ammunition, and most police ammunition requirements specify that it does not defeat the police armour. This is, however, a requirement, which needs to be assessed during the specification stage of both the ammunition and the armour.

7. SUMMARY

Military and Police ammunition are designed differently to meet different requirements. Military ammunition is designed to produce casualties and to supress hostile forces. Police ammunition is designed to rapidly incapacitate, usually a single target, whilst managing the risk of injury to innocent bystanders. For this reason, military ammunition is of the FMJ design, whereas much police ammunition is now of the expanding design.

The differences in behaviour of FMJ and expanding ammunition in tissue can be demonstrated using shots into ballistic gelatine, where parameters such as depth of penetration, maximum volume of temporary cavity and recovered retained bullet mass, can be obtained. Although the wound ballistics parameters measured do not impinge on the design of the armour they are the results of the different designs of projectile, to meet a specific operational requirement. The need for different wound ballistics characteristics leads to a necessary different design of the bullet. This means that the geometry of the nose of the bullet impacting armour is therefore different between the two designs. For hard armour this design has little effect upon the terminal ballistics, but for soft armour there is more scope for differences to be observed. It is for this reason that both HO CAST and VPAM have included expanding hollow point ammunition within their standards as well as FMJ ammunition.

The question as to whether the tested ammunition should, or should not, defeat the users own armour is one of very different views. Usually, the preferable decision is for the user's body armour to be capable of defeating the user's ammunition. This is, however, a requirement, which needs to be assessed during the specification stage of both the ammunition and the armour.

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